BRIDGE DECK EXPANSION JOINTS

Over the years, many different expansion device systems have been used on our bridges. Most have developed problems that have resulted in the need for replacement. Additionally; significant damage to substructures, bearings and girder ends has resulted from leaking expansion joints. However, no expansion joint system has been found that is entirely problem free.

The primary objective of expansion devices is to allow for expansion and contraction of a bridge structure yet seal the deck and provide protection for bridge girders, bearings and substructure elements from leaking water. An additional objective is to provide a smooth, quiet roadway riding surface.

The armored elastomeric strip seal joints have had the best long term performance and are the recommended joint for use on all new construction, at the ends of approach slabs, and at any joint with anticipated movement of 100 mm (4”) or less. For details of these expansion devices, refer to CDOT Staff Bridge WorkSheets series B-518 and B-601-1.

For movements greater than 100 mm (4”), modular joints consisting of multiple elastomeric strip seals are recommended. For typical details of modular expansion devices refer to CDOT Staff Bridge Worksheets Series B-518.

Proper design and application of expansion joints are essential. Skews, horizontal and vertical alignment, grade and cross slopes should all be considered when selecting and designing a joint system. For projects that will have concrete pavement and unprotected concrete decks, it is recommended that the expansion joints be installed in prepared blockouts after the final pavement is in place and all irregularities have been corrected. This will allow adjusting the final profile of the joint to match the adjacent pavement. Refer to CDOT Staff Bridge Design Manual Subsection 7.2 for criteria regarding the structure length requiring bridge expansion devices.

Proper installation is the key to the adequate performance of a well designed joint. To facilitate proper alignment of joints, the bridge geometry should include a bent line with finished grade elevations at the center line of the expansion joint. Elevations are required at all curb faces, grade breaks, and at intervals sufficient to define the profile along the joint on any curve and skew. Joints should be installed in one continuous unit if at all possible.

The asphaltic plug joint system that gained recent popularity due to its ease of construction has not preformed as well as the elastomeric strip seal joints. Because of its limited movement capabilities and relatively high costs, it shall not be considered for new construction. This type of joint has only limited application for emergency repairs and temporary installation.

Use of elastomeric concrete headers is not encouraged. Removal and reconstruction of the joint anchorage portion of bridge decks is the recommended repair procedure for joints and the installation of 0-100 mm (0-4 inch) or modular expansion devices.

DESIGN PROCEDURE FOR 0" TO 4" EXPANSION DEVICE

1. Determine the portion of total length of structure that will contribute to movement at the joint under consideration.

2. For STEEL superstructures, the temperature range shall be 150˚ (F) and the coefficient for thermal expansion shall be 0.0000065/(degrees(F)).

   For CONCRETE superstructures, the temperature range shall be 90˚ (F) and the coefficient for thermal expansion shall be 0.000006/(degrees (F)).

3. The sine of the skew angle between the center line roadway and the joint shall be used to determine the horizontal component of movement normal to the expansion device.

4. For STEEL girder bridges, the horizontal component due to thermal movement shall be multiplied by 1.30. This is an empirical factor which accounts for a factor of safety, movement not normal to joint, and live load rotations.

   For CONCRETE girder bridges, the horizontal component due to thermal movement shall be multiplied by an empirical factor of 2.00. This accounts for a factor of safety, movement not normal to joint, live load rotations, differential shrinkage, creep, moisture content, and elastic shortening.

5. In the formula below, total horizontal movement normal to expansion device shall = HM.

   HM = L(TR) (ct) (sine skew) (tn)
   l = maximum contributory length in inches
   tr = temperature range of steel or concrete from step 2
   ct = coefficient of thermal expansion of steel or concrete from step 2
   skew = skew angle defined in step 3
   tn = empirical factors for steel or concrete from step 4

6. If hm exceeds 4", stop. you cannot use this design aid. you must use the design aid for modular type expansion devices. If hm is less than 4", you are ready to determine the "a" dimension in the chart on page 2 of this Subsection.

STRUCTURE TEMPERATURE (T) ^{o}F	"A" INCHES
30	
40	
50	
60	
70	
80	
90	
100	

For steel girders, use the following formula:

$$A = HM/1.30 + (40 - T)\,(HM/150)$$

$$= HM(2020 - 13T)/1950$$

For concrete girders, use the following formula:

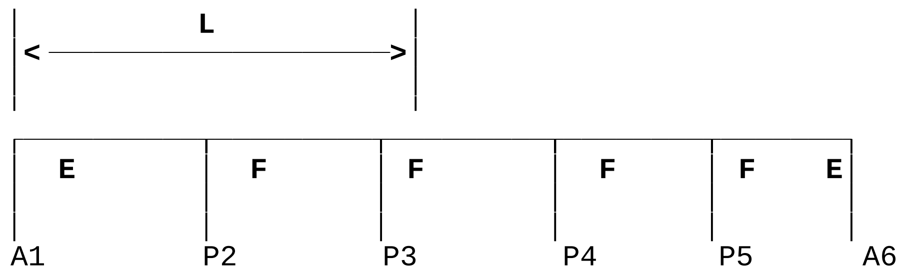
$$A = 0.25 + HM(100 - T)/(2.00)\,(90)$$

The 0.25" is the minimum opening to be set during placement of the device at 100˚ (F). In other words, the device may never be completely closed when it is placed. You may, however, use 3/16" as a minimum opening during placement of the device when determining the "A" dimension.

The examples that follow on pages 3 and 4 are to be used as a guide for using the above formulas. These examples may not reflect actual conditions or constraints of your bridge.

EXAMPLE:

Determine the "A" dimension for 0" to 4" expansion devices at abutments 1 and 6 for a 5 span (100’-0", 100’-0", 130’-0", 100’-0", 100’-0") Welded Plate Girder Continuous Bridge, skewed 53 degrees.



SOLUTION:

1. L = (100 + 100 + 130/2) (12) = 3180"

2. ct = 0.0000065/(˚F), TR = 150 (˚F)

3. Skew = 53 degrees

4. TN = 1.30

5. HM = (3180)(150)(.0000065)(sin 53)(1.30) = 3.219" < 4" OK

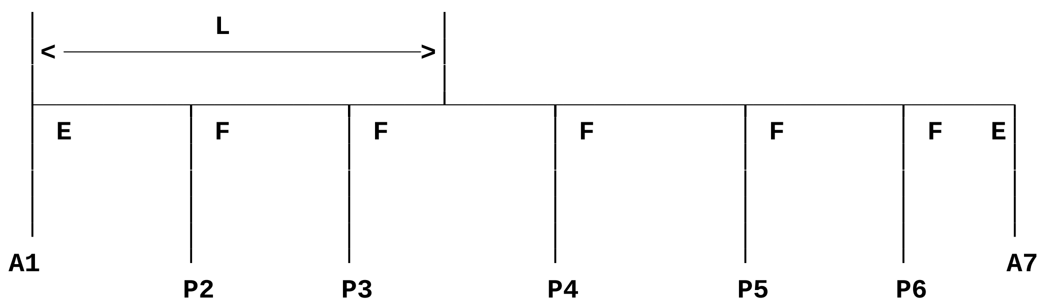
6. A = 3.219(2020 - 13(30))/1950 = 2.691" @ 30 degrees (F)
   A = 3.219(2020 - 13(40))/1950 = 2.479" @ 40 degrees (F)
   A = 3.219(2020 - 13(50))/1950 = 2.262" @ 50 degrees (F)
   A = 3.219(2020 - 13(60))/1950 = 2.046" @ 60 degrees (F)
   A = 3.219(2020 - 13(70))/1950 = 1.832" @ 70 degrees (F)
   A = 3.219(2020 - 13(80))/1950 = 1.618" @ 80 degrees (F)
   A = 3.219(2020 - 13(90))/1950 = 1.403" @ 90 degrees (F)
   A = 3.219(2020 - 13(100))/1950 = 1.189" @ 100 degrees (F)

Rounding to the nearest 1/16", complete chart.

STRUCTURE TEMPERATURE °F	"A" INCHES
30	2 11/16
40	2 1/2
50	2 1/4
60	2 1/16
70	1 13/16
80	1 5/8
90	1 3/8
100	1 3/16

EXAMPLE:

Determine the "A" dimension for 0" to 4" expansion devices at abutments 1 and 7 for a 6 span (85'-0", 85'-0", 140'-0", 140'-0", 85'-0", 85'-0"). Prestressed Concrete Girder Continuous Bridge, skewed 67 degrees.



SOLUTION:

1. L = (85 + 85 + 140)(12) = 3720"

2. ct = 0.000006/(deg. F), TR = 90 Degrees F

3. Skew = 67 degrees

4. TN = 2.00

5. HM = (3720)(90)(.000006)(sin 67)(2.00) = 3.698" < 4" OK

6. A = 0.25 + 3.698(100 - 30)/180.0 = 1.688" @ 30 degrees F
A = 0.25 + 3.698(100 - 40)/180.0 = 1.483" @ 40 degrees F
A = 0.25 + 3.698(100 - 50)/180.0 = 1.277" @ 50 degrees F
A = 0.25 + 3.698(100 - 60)/180.0 = 1.072" @ 60 degrees F
A = 0.25 + 3.698(100 - 70)/180.0 = 0.866" @ 70 degrees F
A = 0.25 + 3.698(100 - 80)/180.0 = 0.661" @ 80 degrees F
A = 0.25 + 3.698(100 - 90)/180.0 = 0.455" @ 90 degrees F
A = 0.25 + 3.698(100 - 100)/180.0 = 0.250" @ 100 degrees F

Rounding to nearest 1/16", complete chart.

STRUCTURE TEMPERATURE ^{o}F	"A" INCHES
30	1 11/16
40	1 1/2
50	1 1/4
60	1 1/16
70	0 7/8
80	0 11/16
90	0 7/16
100	0 1/4

DESIGN PROCEDURE FOR MODULAR EXPANSION DEVICE

1. Determine the portion of total length of structure that will contribute to movement at the joint under consideration.

2. For STEEL superstructures, the temperature range shall be 150° (F) and the coefficient for thermal expansion shall be 0.0000065/f (F).

   For CONCRETE superstructures, the temperature range shall be 90˚ (F) and the coefficient for thermal expansion shall be 0.000006/f (F).

3. The skew angle is defined as the angle between the center- line roadway and the center-line joint. If motion is not parallel to center line roadway (curved bridges, for instance), use the line of motion instead of center-line roadway. For a skew angle greater than or equal to 45f, the sine of the skew angle shall be used to determine the horizontal component of movement normal to the expansion device. For a skew angle less than 45f, racking of the device becomes significant, and therefore, the device must be designed to absorb the total movement in the direction of the center-line roadway (sine skew = 1). In other words, the device will, of course, be built along the skew, but it will be sized and the "A" dimension chart filled out as though the device was normal to the center-line roadway.

4. For STEEL girder bridges, the horizontal component due to thermal movement shall be multiplied by 1.30. This is an empirical factor which accounts for a factor of safety, movement not normal to joint, and Live Load rotations.

   For CONCRETE girder bridges, the horizontal component due to thermal movement shall be multiplied by an empirical factor of 2.00. This accounts for a factor of safety, movement not normal to joint, Live Load rotations, differential shrinkage, and creep.

5. In the formula below, HMED = the size of the modular expansion device required. HMED should be rounded up to the nearest 3 inch increment.

   HMED = L(TR)(ct)(sine skew)(TN)
   L = maximum contributory length in inches
   TR = temperature range of steel or concrete from step 2
   ct = coefficient of thermal expansion of steel or concrete from step 2
   Skew = skew angle defined in step 3
   TN = empirical factors for steel or concrete from step 4

6. If HMED is less than 4", STOP. You cannot use this design aid. You must use the design aid for 0-4 inch Expansion Devices. If HMED is greater than 4", you are ready to determine the "A" dimension in the chart. A standard modular device cannot handle a HMED dimension greater than 22 inches.

A modular expansion device consists of premolded elastomeric expansion joint seals mechanically held in place by extruded steel separation beams.

Each elastomeric seal can absorb 3" of structure movement. Therefore, the device shown above is a 0-9 inch device. A 0-12 inch device would have one more elastomeric seal and one more separation beam, and so on.

STRUCTURE TEMPERATURE (T) °F	"A" INCHES
30	
40	
50	
60	
70	
80	
90	
100	

For STEEL GIRDERS, the elastomeric seals should be half closed at the median temperature of 40° (F). Therefore,

A(40°) = (l-l/2") (No. of elastomeric seals) + (3") (No. of separation beams)

To complete the "A" dimension chart, add or subtract the following unfactored 10° increment to A(40°):

$$\text{Increment} = \frac{\text{HMED}}{(1.30)}\,\frac{(10)}{(150^\circ)}$$

For CONCRETE GIRDERS, each elastomeric seal should be 1/4" open at 100° (F). Therefore,

A(100°) = (l/4") (No. of elastomeric seals) + (3") (No. of separation beams)

This results in a more closed device initially than would be obtained using the steel girder procedure. The purpose of this is to allow for creep (in prestressed girders) and shrinkage which will open the device over time. To complete the "A" dimension chart, add the following unfactored 10° increment to A(100°):

$$\text{Increment} = \frac{\text{HMED}}{(2.00)}\,\frac{(10^\circ)}{(90^\circ)}$$

The acceptable manufacturer's alternates for modular devices are:

Wabo-Maurer - as furnished by:

Watson-Bowman Acme
95 Pineview Drive
Amherst, New York, 14120 Tel (716) 691-7566

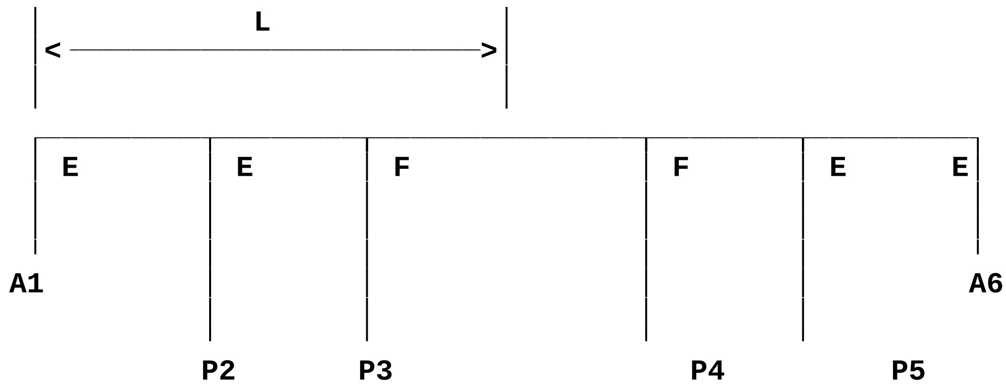
Maurer - as furnished by:

D. S. Brown Company
P.O. Box 158
North Baltimore, Ohio 45872 Tel (419) 257-3561

The example that follows is to be used as a guide for using the above formulas. This example may not reflect actual conditions or constraints of your bridge.

EXAMPLE:

Determine the "A" dimension for modular expansion devices at abutments 1 and 6 for a 5 span (200′-0", 200′-0", 230′-0", 200′-0", 200′-0") Welded Plate Girder Continuous Bridge, skewed 53 degrees.



SOLUTION:

1. L = (200 + 200 + 230/2) (12) = 6180"

2. ct = 0.0000065/(˚F), TR = 150˚ (F)

3. Skew = 53˚

4. TN = 1.30

5. HMED = (6180) (150) (0.0000065) (sine 53) (1.30) = 6.26" > 4" OK

6. Use 0-9 Inch Modular

   A(40˚) = (1-1/2)(3)+ (3")(2) = 10.5"

   Increment = $\frac{(6.26)(10)}{(1.3)(150)}$ = 0.32 use 5/16"

The completed chart is shown:

STRUCTURE TEMPERATURE ^{o}F	"A" INCHES
30	10 13/16
40	10 1/2
50	10 3/16
60	9 7/8
70	9 9/16
80	9 1/4
90	8 15/16
100	8 5/8